



Litholog generation with the Stratigrapher package and signal decomposition for cyclostratigraphic purposes

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To establish an astronomical time scale, it is useful to perform a visual inspection of the lithological evolution, together with proxies record. It allows to have a clear understanding of the expression of Milankovitch cyclicality. However, performing such an inspection can be challenging due to the large amount of data and high spatial resolution required to perform a sound cyclostratigraphic analysis.

To address this problem we present the Stratigrapher package in the free software environment R (<https://CRAN.R-project.org/package=Stratigrapher>). This package is designed to generate lithologs and to deal with stratigraphical information. Stratigrapher takes advantage of the repetitive nature of sections used for cyclostratigraphic purposes to automate as much as possible the litholog generation while still allowing the visualisation of discrepancies (e.g. lateral variations of thickness and irregular stratification boundaries) and of any particular features (e.g. fossil content, sedimentary structures, stratigraphical intervals, etc.). The package furthermore allows to import vector graphics as SVG files, to export the lithologs in PDF and SVG form, to manipulate stratigraphic interval data and to visualise oriented palaeomagnetic data.

The lithologs made in Stratigrapher can be plotted at high resolution directly along the results of time series filtering and/or decomposition methods. This is particularly useful for high-frequency components inspection. Empirical Mode Decomposition (EMD) in particular can be used for visual inspection. It allows to compute different components -also called modes- by iteratively subtracting from the signal the mean envelope curves, defined by local minima and maxima. In the isolated modes, each contiguous local extrema are separated by a zero-crossing. This property furthermore allows the determination of instantaneous frequency and amplitude, using for instance the Hilbert transform. EMD typically decomposes standard cyclostratigraphic time series in maximum 15 modes, which allows all the instantaneous ratios of the modes frequencies - taken two by two- to be calculated in a realistic computational time. These instantaneous ratios of frequencies can then be used to find the signature of Milankovitch cycles by identifying relatively higher ratios distributions at values characteristic of the orbital cycles. Specific ratios intervals can then be isolated and linked back to the parts of the signal that are at their source.